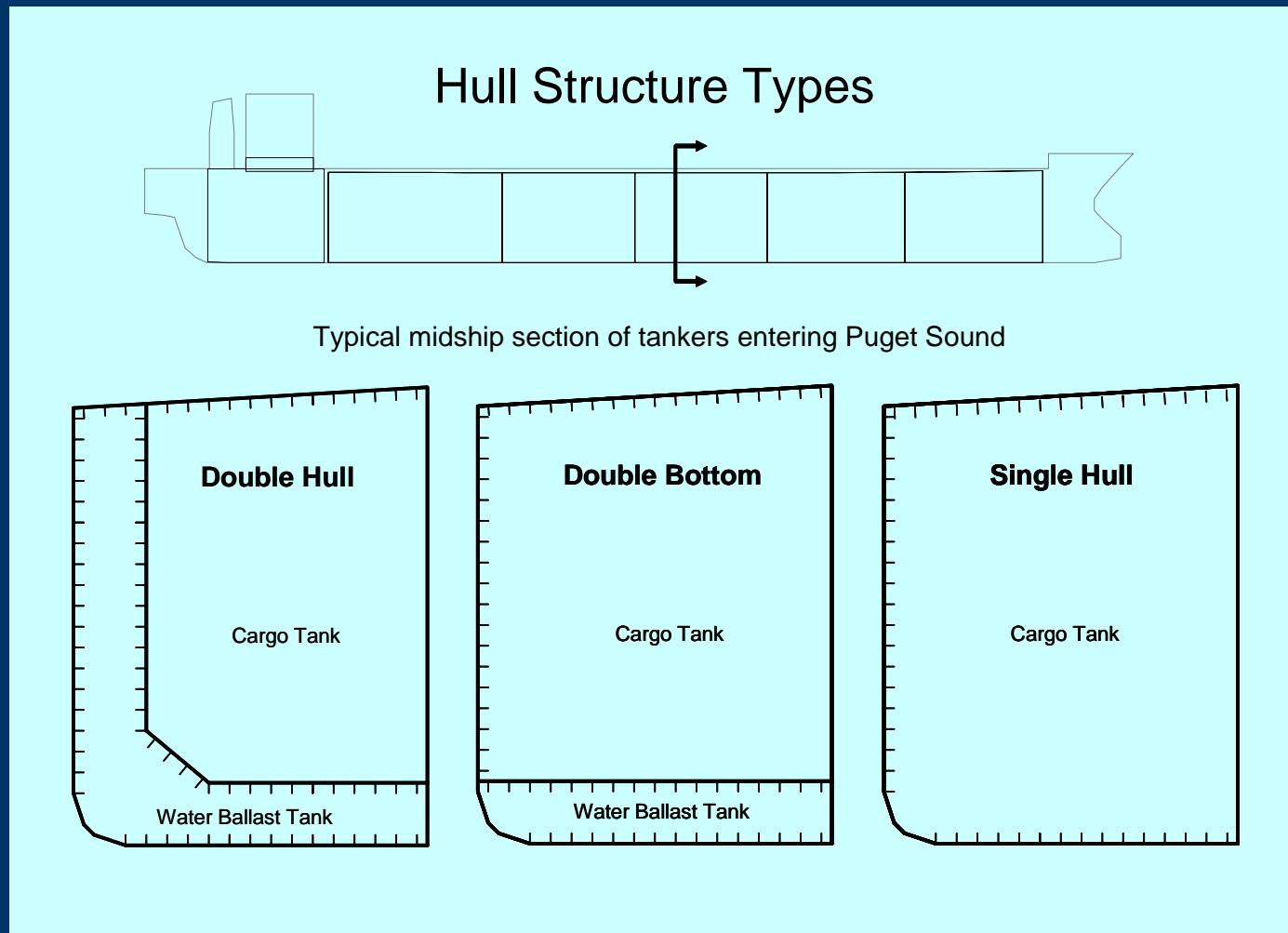


Study of Tug Escorts in Puget Sound Probabilistic Oil Outflow Evaluation



Seattle, December 8, 2004

Typical Single and Double Hull Structures

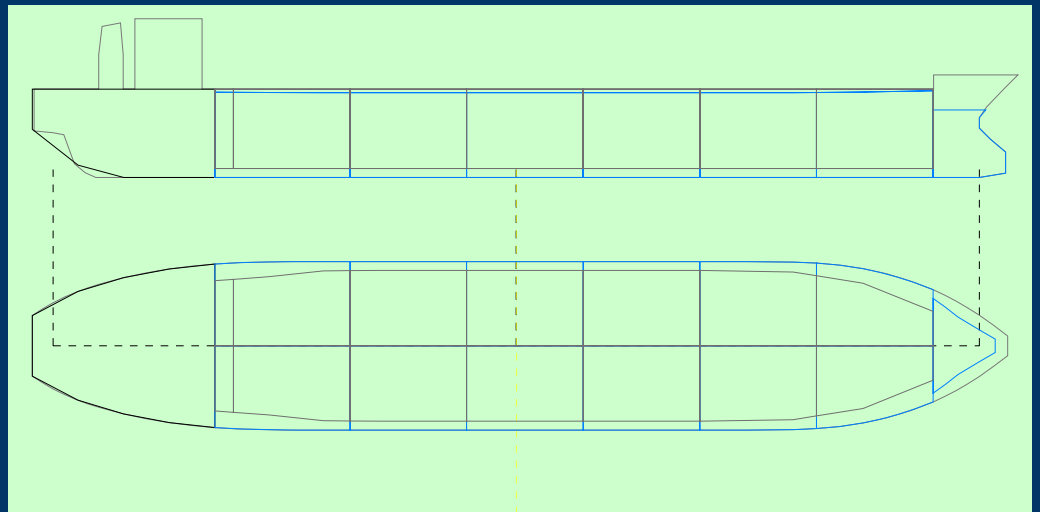


Baseline Ship – 6 x 2 SuexMax Double-hull

Principal Characteristics

- LBP 260.4 m
- Beam 47.435 m
- Depth 23.673 m
- Draft (PS) 14.8 m
- DWT (full) 150,000 MT
- DWT (PS) 125,000 LT

A 125,000 DWT tanker is unlikely to be built for economic reasons as it would be inefficient for other trades



Loading of Polar and ATC Tankers

Polar Endeavour Class is 142,000 dwt

ATC Alaska Class is 185,000 dwt

Each vessel is loaded to a 125,000 DWT for Puget Sound deliveries.

Polar Endeavour class

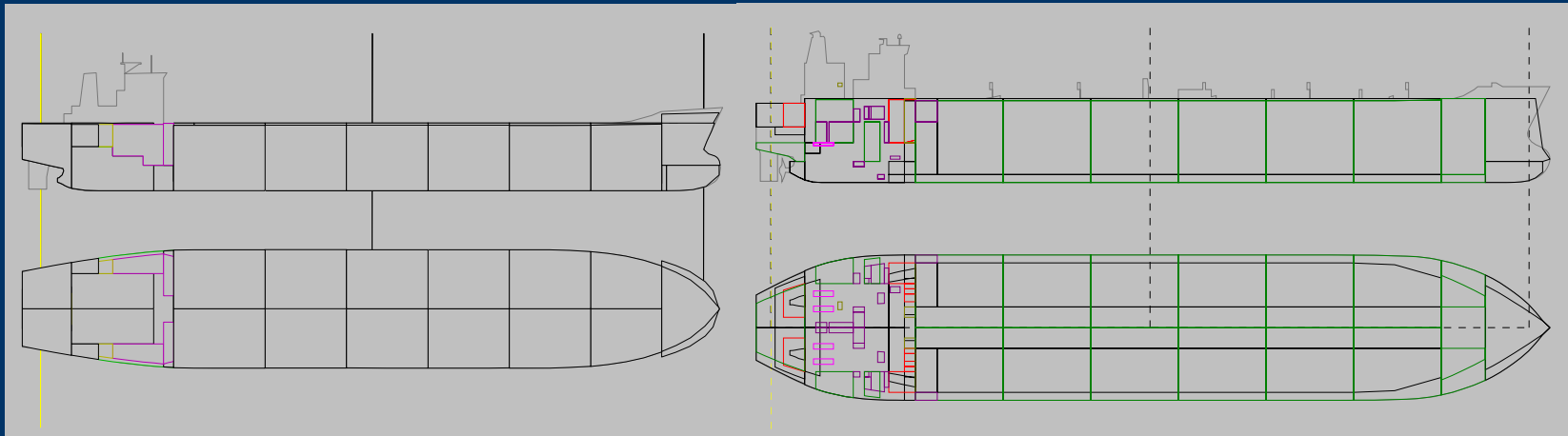
ATC Alaska class

Tanks 2, 3, 4 and 6 loaded to 98%.

Checkerboard loading.

Tanks 1 loaded to 65%.

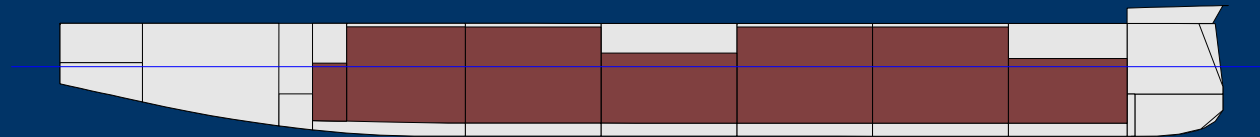
Tanks 5 loaded to 77%.



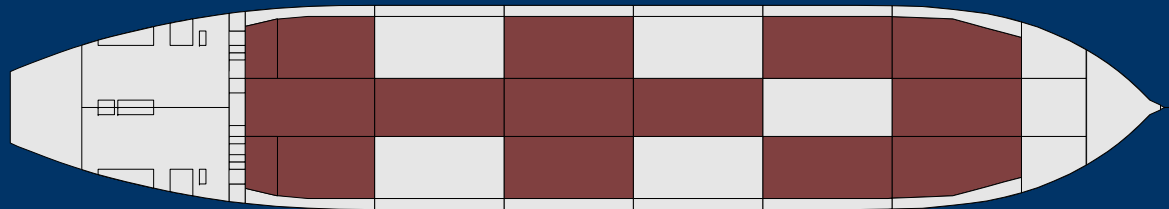
Polar Endeavour Class

ATC Alaska Class

125,000 dwt loading approach

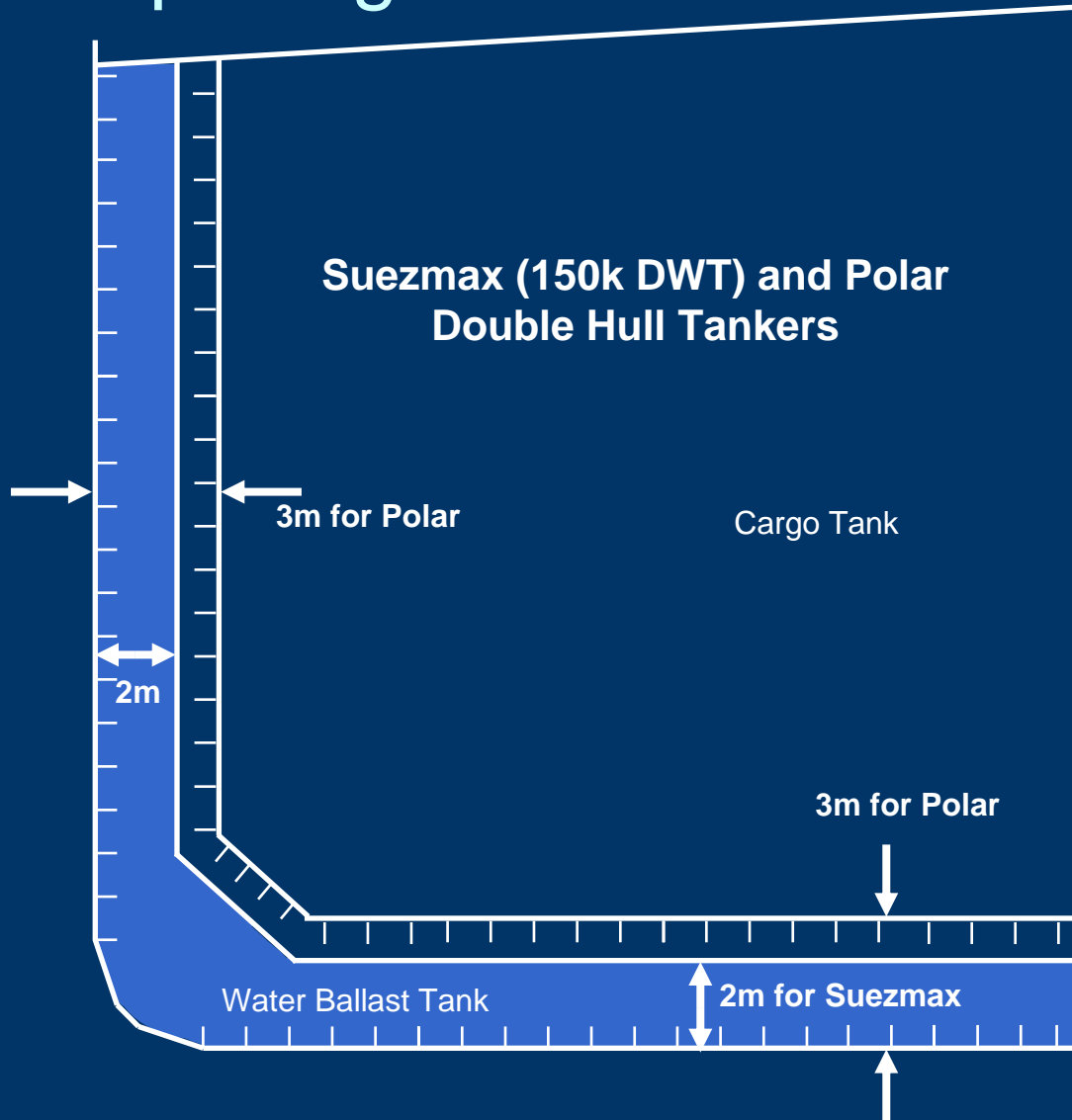


Polar Endeavour Class
Profile view



ATC Alaska Class
Plan view

Typical and Polar Millennium Double Hull Spacing



Double Hull Dimensions

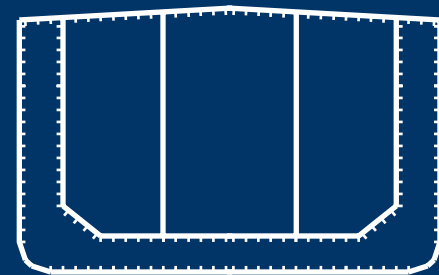
Suezmax = 2m*

BP ATC = 2.7m

Polar = 3.0m

* Future MARPOL regulations to be adopted in 2006 require oil outflow performance requirements.

- Approximately 2.5m double hull for 6x2 cargo arrgt.
- Approximately 2.3m double hull for 6x3 cargo arrgt.

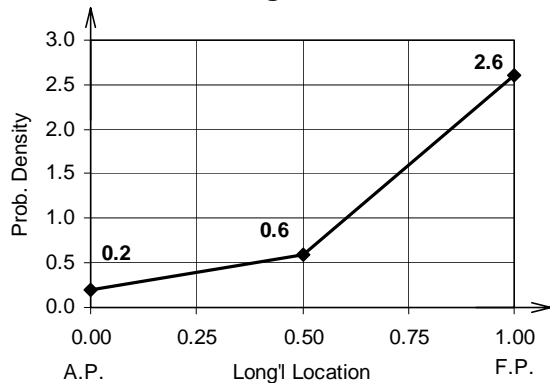


Probabilistic Oil Outflow Methodology

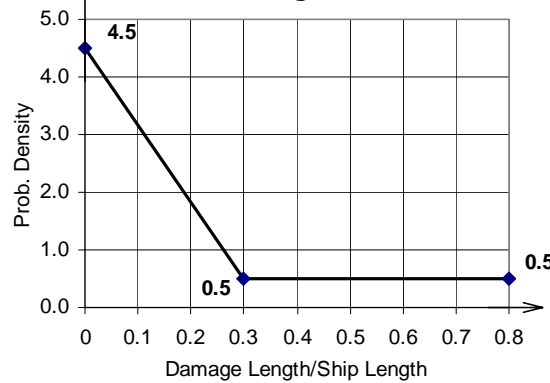
- Define intact condition.
- Assemble damage cases and their associated probabilities of occurrence for both side (collisions) and bottom damage (groundings).
- Calculate oil outflow for each damage case.
- Calculate oil outflow parameters.
 - Probability of zero oil outflow
 - Expected (mean) oil outflow
 - Extreme (average of highest 1/10) oil outflow

PDF's from IMO & OPA 90 Regulations

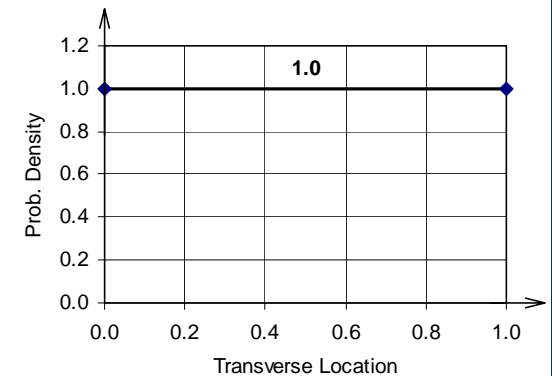
BOTTOM: Longitudinal Location



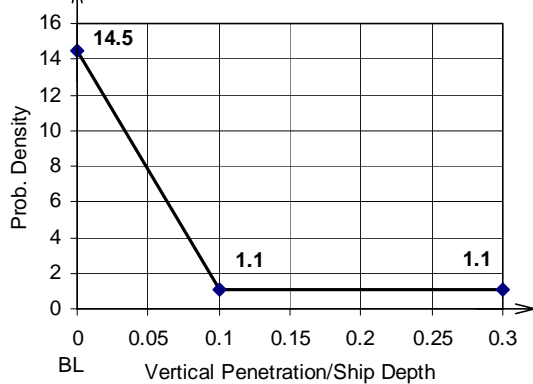
BOTTOM: Longitudinal Extent



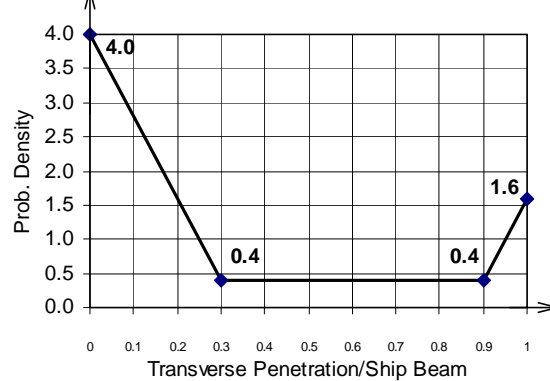
BOTTOM: Transverse Location



BOTTOM: Vertical Penetration



BOTTOM: Transverse Extent

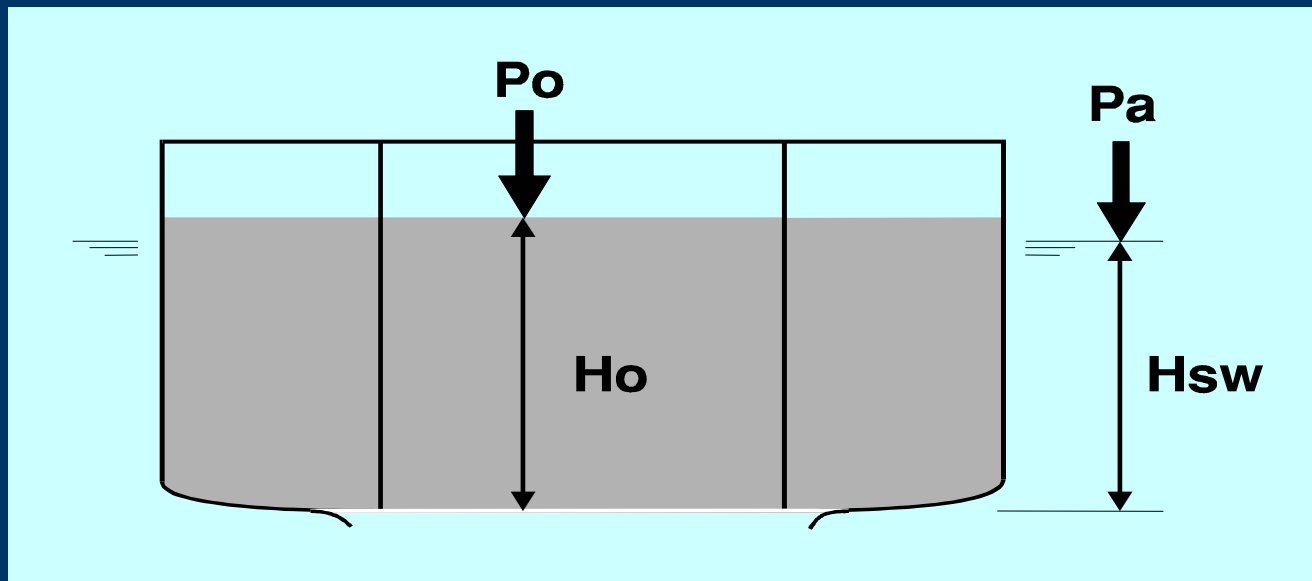


Hydrostatic Pressure Balance

Internal Pressure = External Pressure

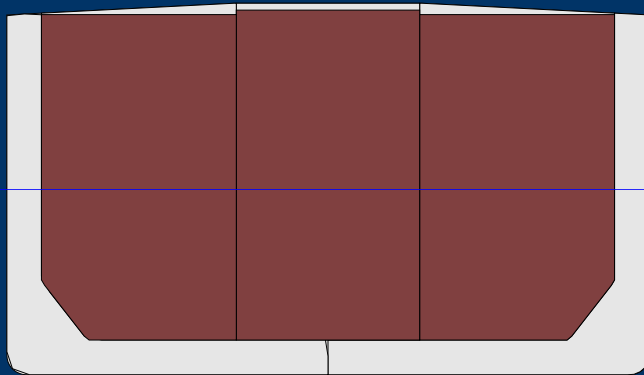
Internal Pressure = $P_o + (H_o) (D_{oil})$

External Pressure = $P_a + (H_{sw}) (D_{sw})$

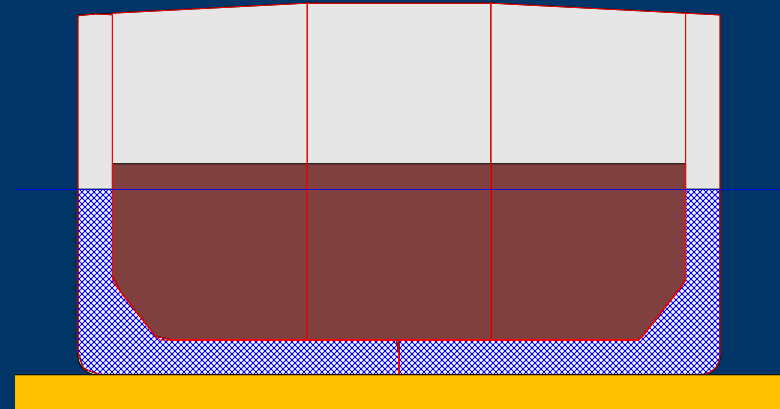


Oil Outflow and Capture

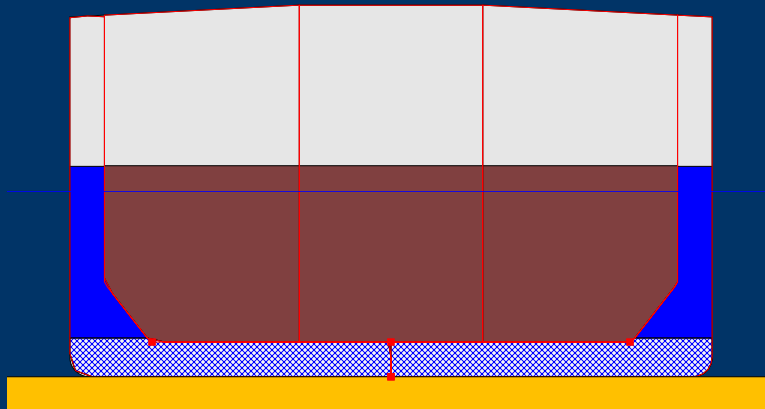
As loaded



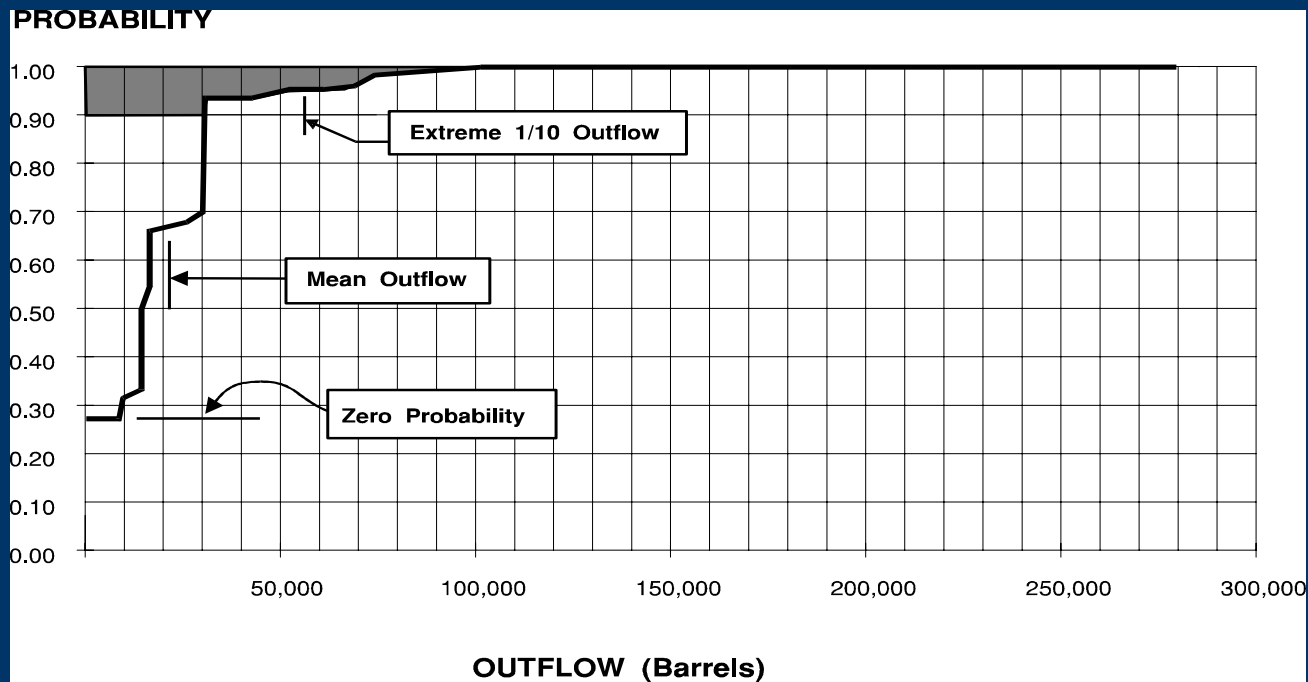
Aground after damage
No capture by double-hull



Aground after damage
Some oil captured by double-hull

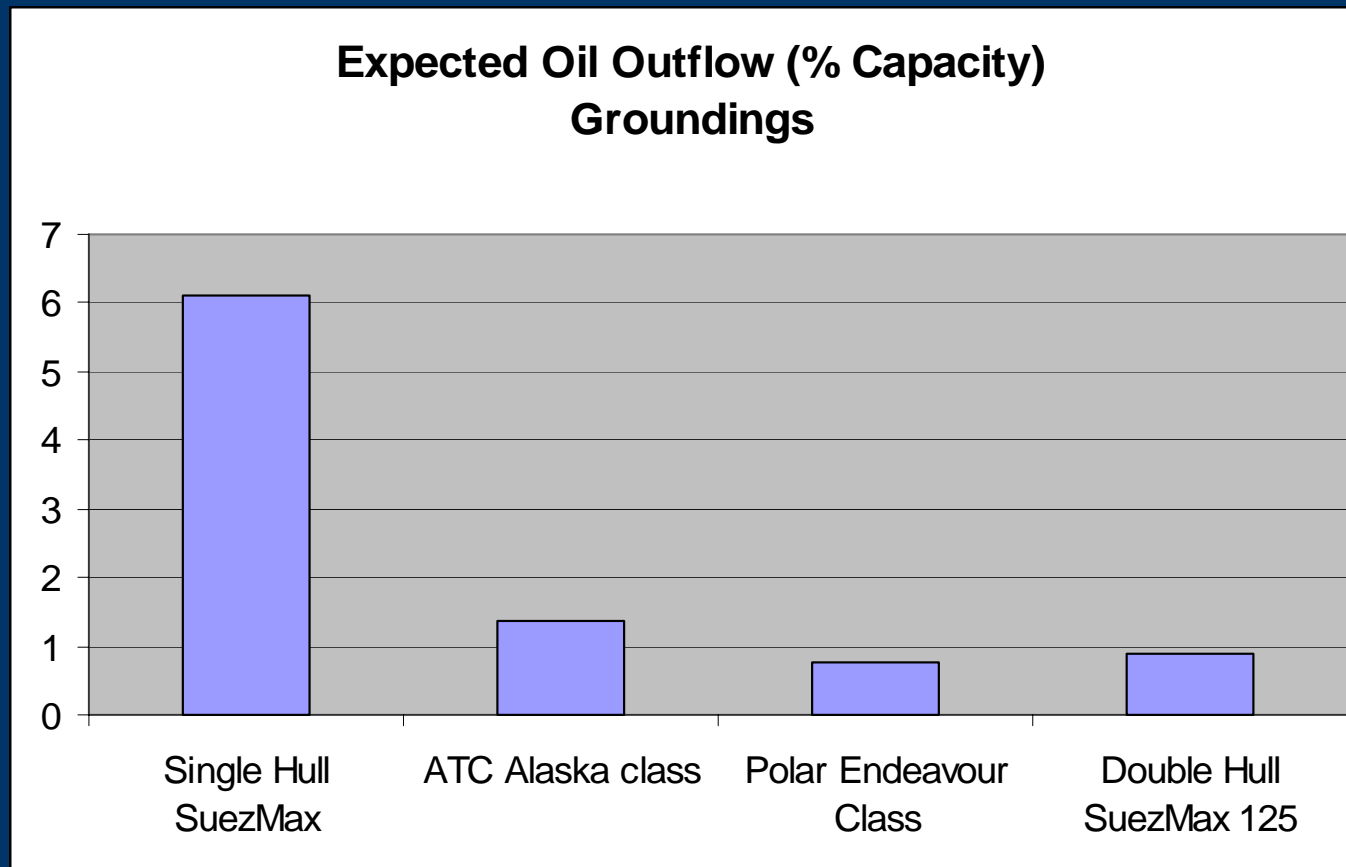


Oil Outflow Parameters

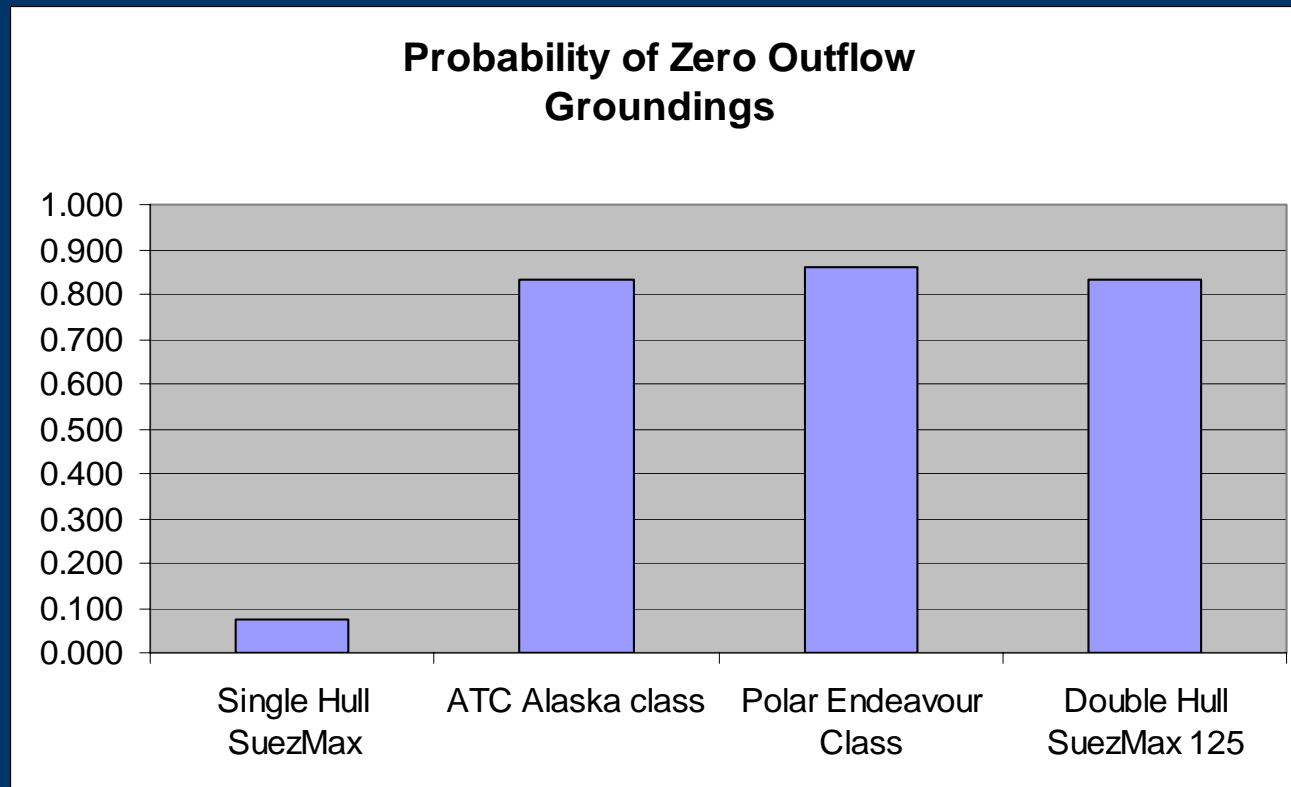


Oil outflow cumulative probability

Mean Oil Outflow in Groundings



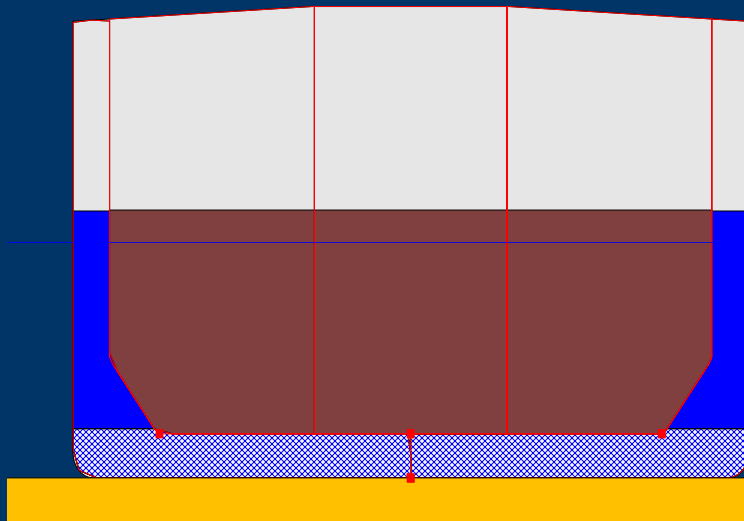
Probability of Zero Outflow Groundings



Influence of PS loading on spill size

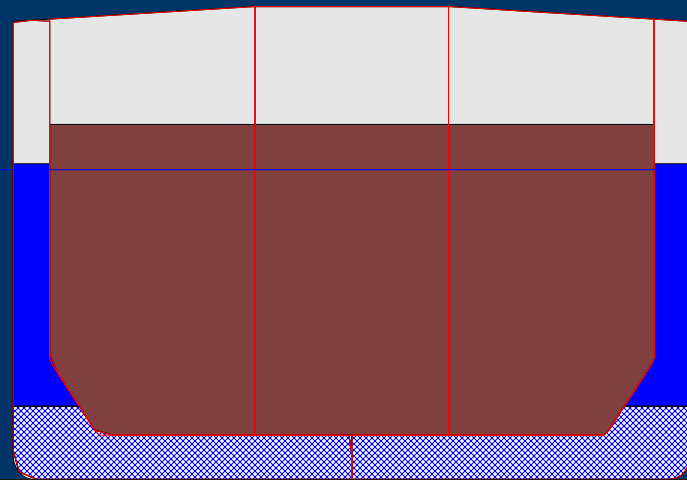
Alaska class

– 125dwt aground



Alaska class

– full load aground



* Deeper draft may lead to more chance of grounding